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High Power Microwave Research, Atmospheric Plasma Phenomena, Ultra-Wideband Propagation and Generation

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This report has been approved for publication.

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14. ABSTRACT

The primary objectives of this effort were to investigate gas breakdown, plasma antennas, and laser induced plasmas in the atmosphere. The contractor investigated the electrical breakdown of different types of gas under very fast transient voltage excitation. The research addresses different types of gas under different conditions of pressure, temperature, and electrical field stress as expressed on a Paschen curve. The contractor also investigated the feasibility of generating and shaping conducting plasma to be used as an antenna and generating a conducting path in the atmosphere using a high power laser.

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gas breakdown, plasma antennas, laser induced plasma, conducting plasma, antenna, high power microwave

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GOVERNMENT SUMMARY

I. Objective:

The primary objectives of this effort were to investigate gas breakdown, plasma antennas, and laser induced plasmas in the atmosphere.

II. Scope:

Although a great deal of data exists on gas breakdown, there are gaps in the published data when dealing with high electric field stresses and very fast risetimes. The scope of this effort was to fill in the gaps with real data. This report is a compilation of articles discussing the findings from the project.

III. Background:

The contractor investigated the electrical breakdown of different types of gas under very fast transient voltage excitation. The contractor developed theoretical models of gas breakdown characteristics and their calculations were compared to laboratory measurements. Subsequently, the calculations were compared to measurements. The research addresses different types of gas under different conditions of pressure, temperature, and electrical field stress as expressed on a Paschen curve. Measurements were made using the H-2 high voltage coaxial source. The contractor also investigated the feasibility of generating and shaping conducting plasma to be used as an antenna and generating a conducting path in the atmosphere using a high power laser. One test set-up was built and measured. The physics involved in the ionization of atmospheric air by an intense laser were investigated, starting with small (mm) sized gaps.

IV. Technical Activities

List of the relevant publications produced under this contract:

1. D.W. Scholfield, J.M. Gahl, and N. Shimomura, "Effective electric field for an arbitrary electromagnetic pulse," *IEEE Transactions on Plasma Science,* Volume 27, Issue 2, April 1999, pp. 628-632.

2. N. Shimomura, D.W. Scholfield, J.M. Gahl, and J. Lester, "Investigation of intense electromagnetic transient phenomenon and Paschen curves for hydrogen and helium in subnanosecond regime," *IEEE Transactions on Plasma Science* Vol. 28, No. 3, June 2000, pp. 496-501.

3. D.W. Scholfield, J.M. Gahl, and N. Shimomura, "Columnar focal lens," *Review of Scientific Instruments,* Vol. 70, No. 5, May 1999, p. 2495-9.

4. William M. White, "Investigation of the Characteristics of Atmospheric Laser Induced Plasmas," Master's Thesis, Dept of Electrical Engineering, The University of New Mexico, Albuquerque, New Mexico, December 2000.

5. J.M. Gahl, J.L. Korioth, W.M. White, and D.W. Scholfield, "Field Emission Peaking Switch Studies,"*Proceedings of the 12th International Pulsed Power Conference,* Monterey, CA, June 1999.

V. Conclusion

As a result of this contract, much of the parameter space not covered by published data has been filled in for the benefit of all researchers. The physics involved in the ionization of atmospheric air by an intense laser demonstrates the ionization of air over a small gap and also reveals some of the physical parameters that will come into play when the gap is made much larger. This investigation is very enlightening and will lay the groundwork for future investigators.

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